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Kobayashi

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[54] **JET PROPULSION UNIT CONDITION INDICATOR**

[75] Inventor: **Noboru Kobayashi**, Iwata, Japan

[73] Assignee: **Yamaha Hatsudoki Kabushiki Kaisha**, Iwata, Japan

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[30] **Foreign Application Priority Data**

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[51] **Int. Cl.**[6] **B63H 11/103**

[52] **U.S. Cl.** **440/47**; 440/38

[58] **Field of Search** 114/270; 440/38, 440/39, 47, 88; 60/221, 222

[56] **References Cited**

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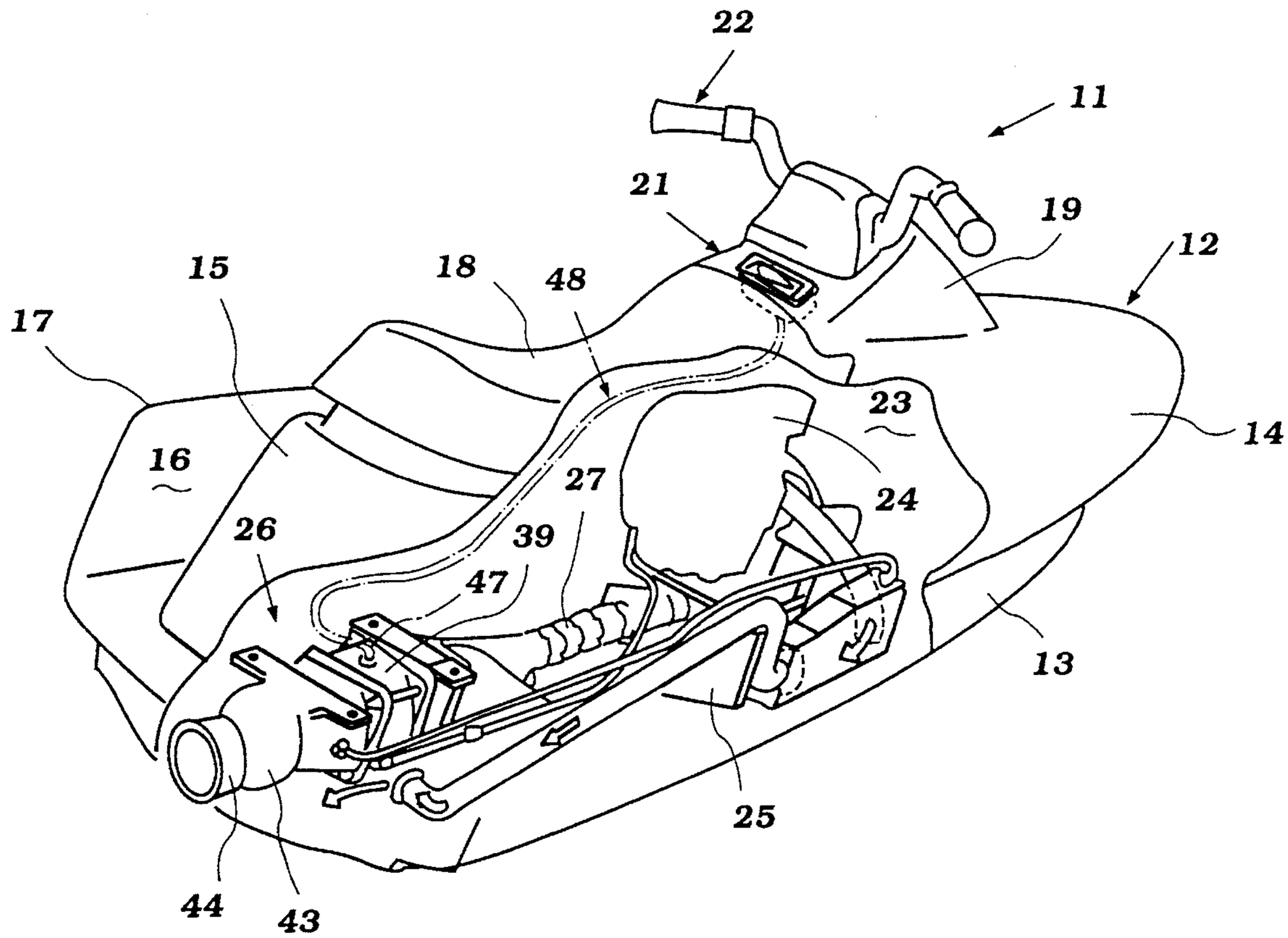
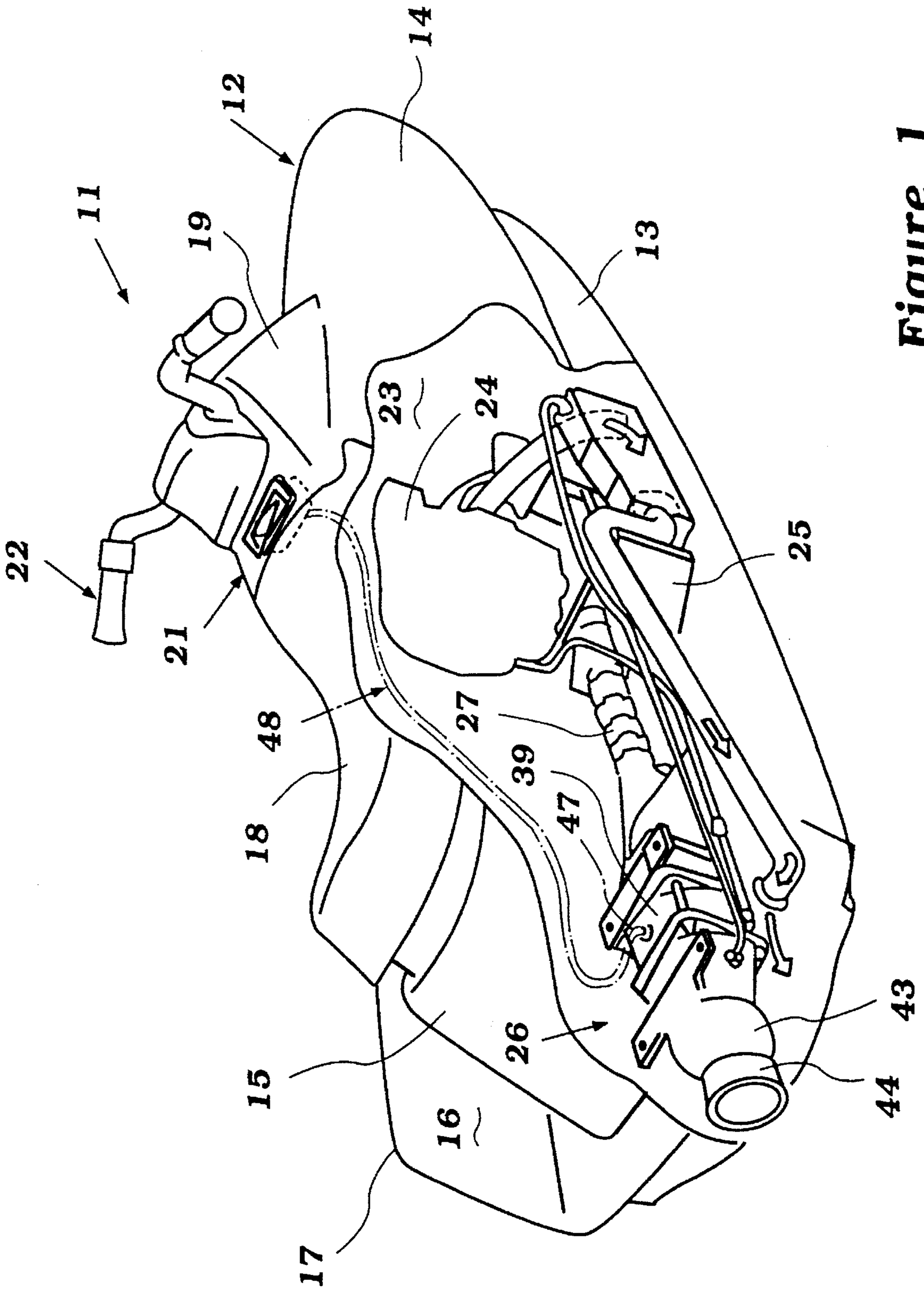
Primary Examiner—Stephen Avila
Attorney, Agent, or Firm—Knobbe, Martens, Olson & Bear LLP

[57] **ABSTRACT**

A number of embodiments of jet-propelled watercraft embodying a combined jet propulsion unit and propulsion unit condition sensor. The condition sensor is contained within the outer housing of the jet propulsion unit and may be formed either in the grilled inlet opening, the water inlet portion, the straightening vane portion, or the discharge nozzle portion.

29 Claims, 5 Drawing Sheets





Figure

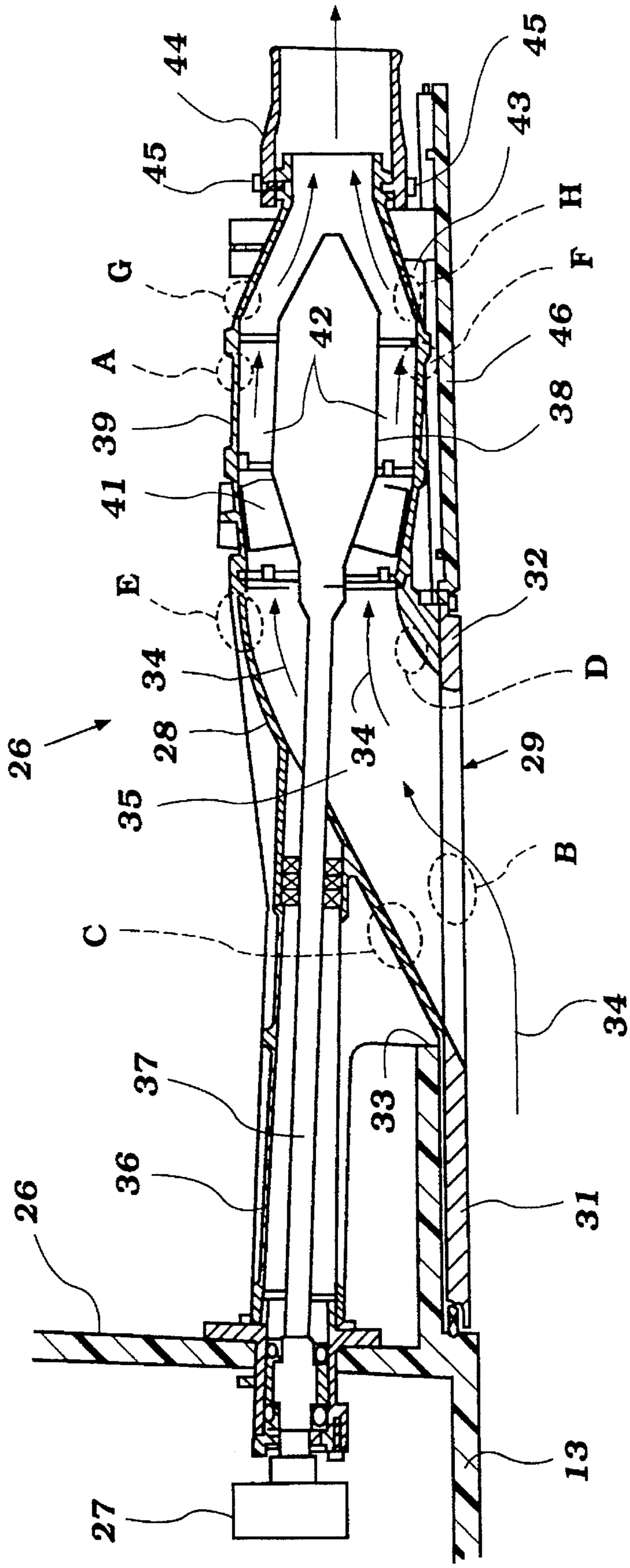

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Figure 2

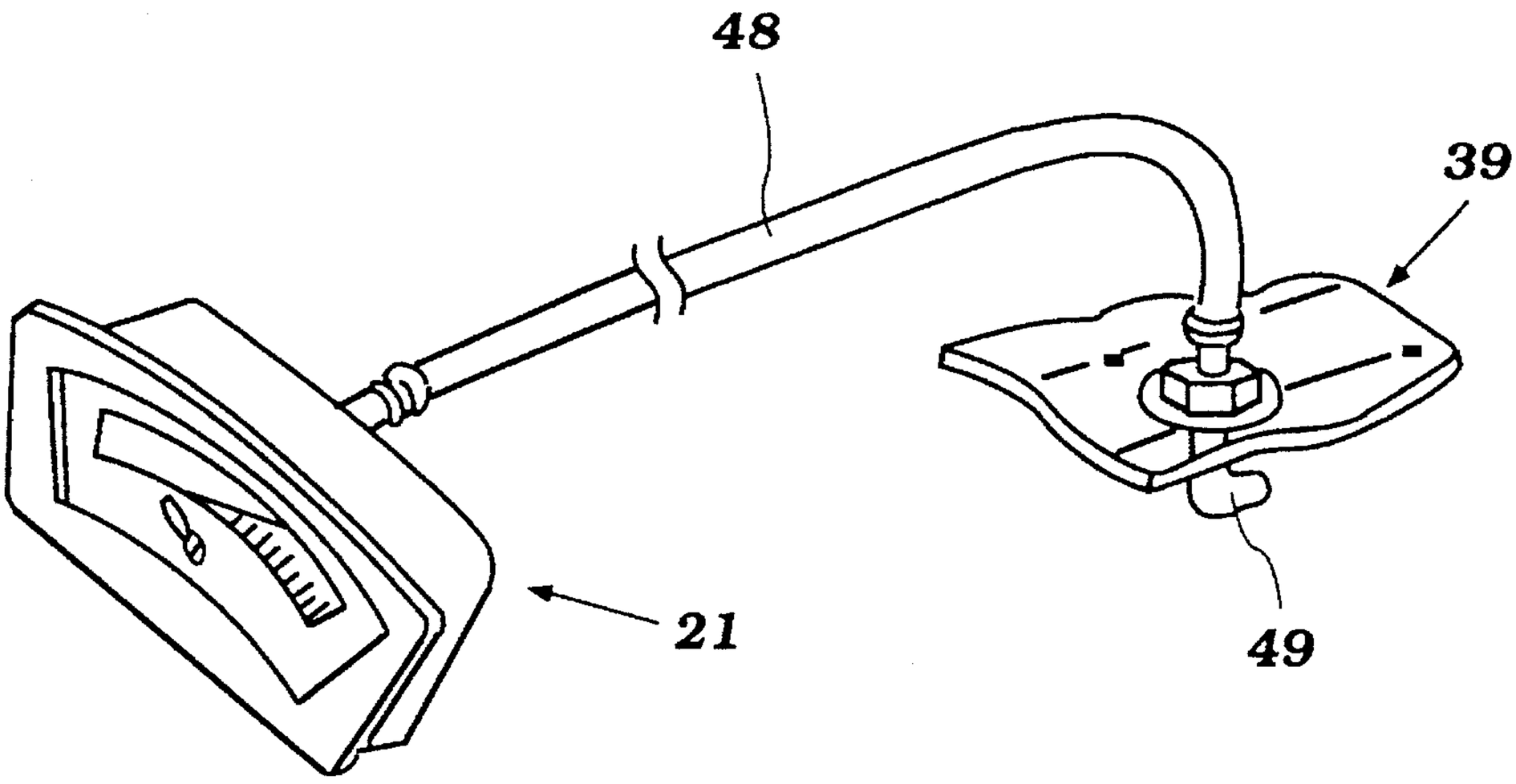

Figure 3

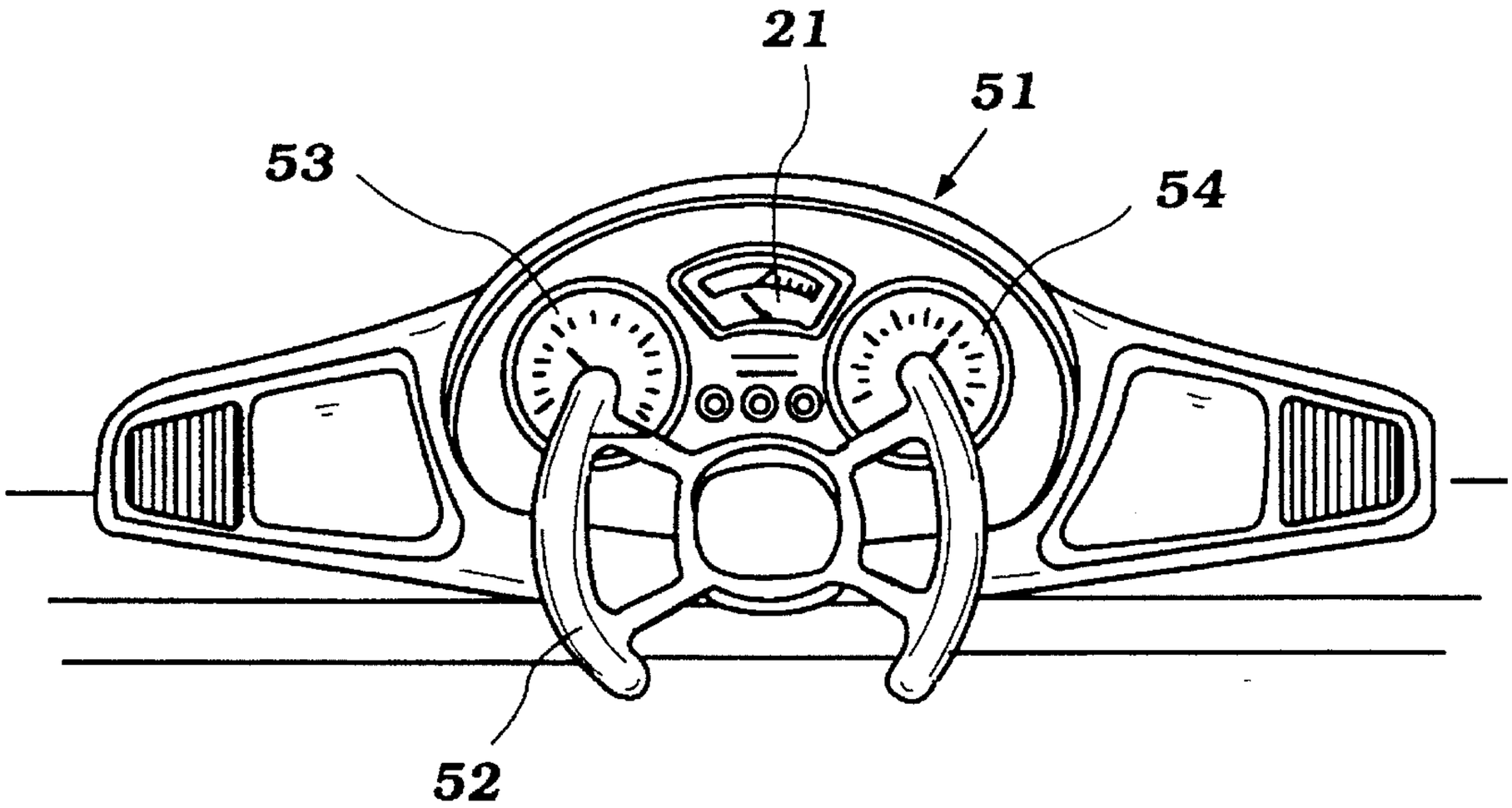

Figure 4

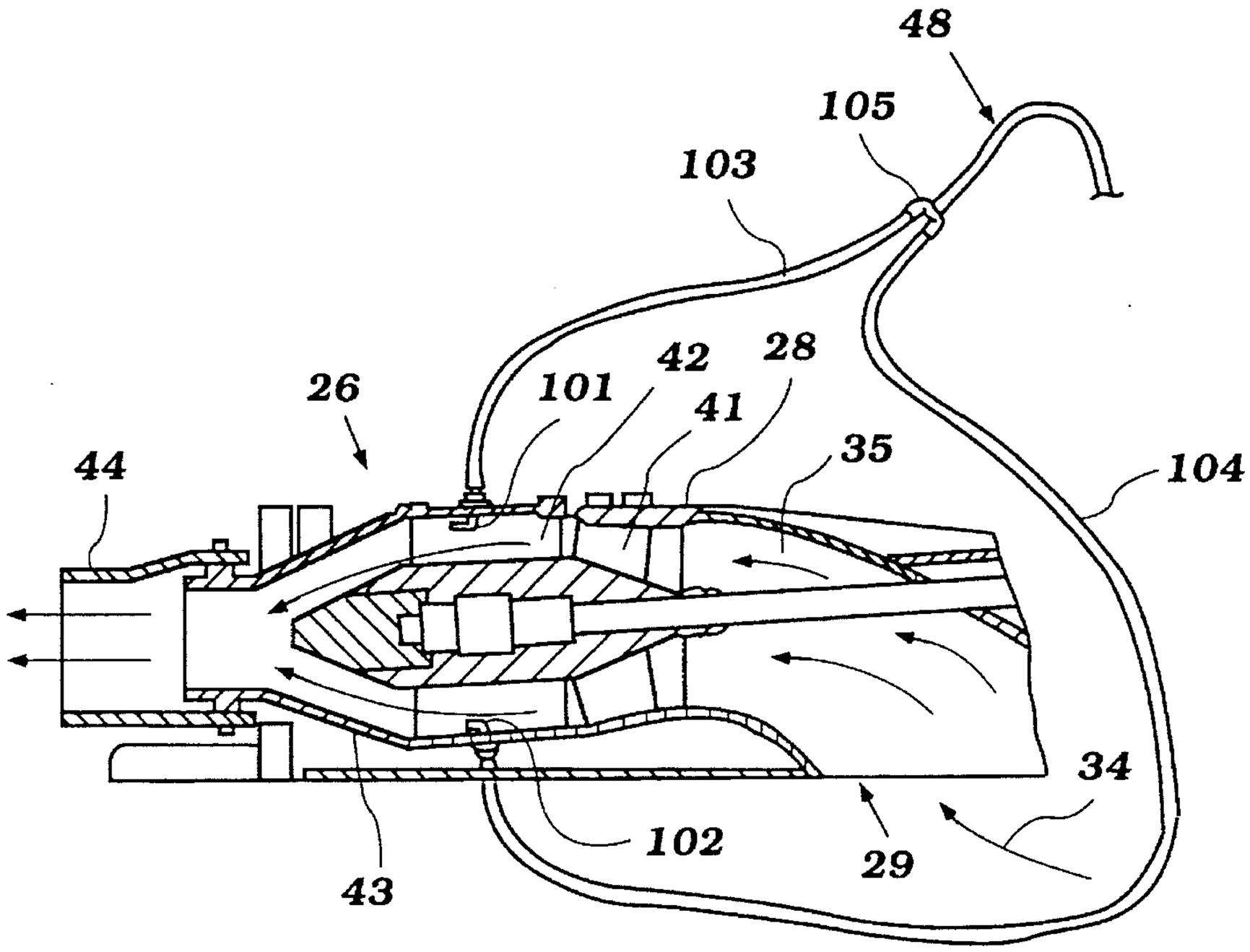

Figure 5

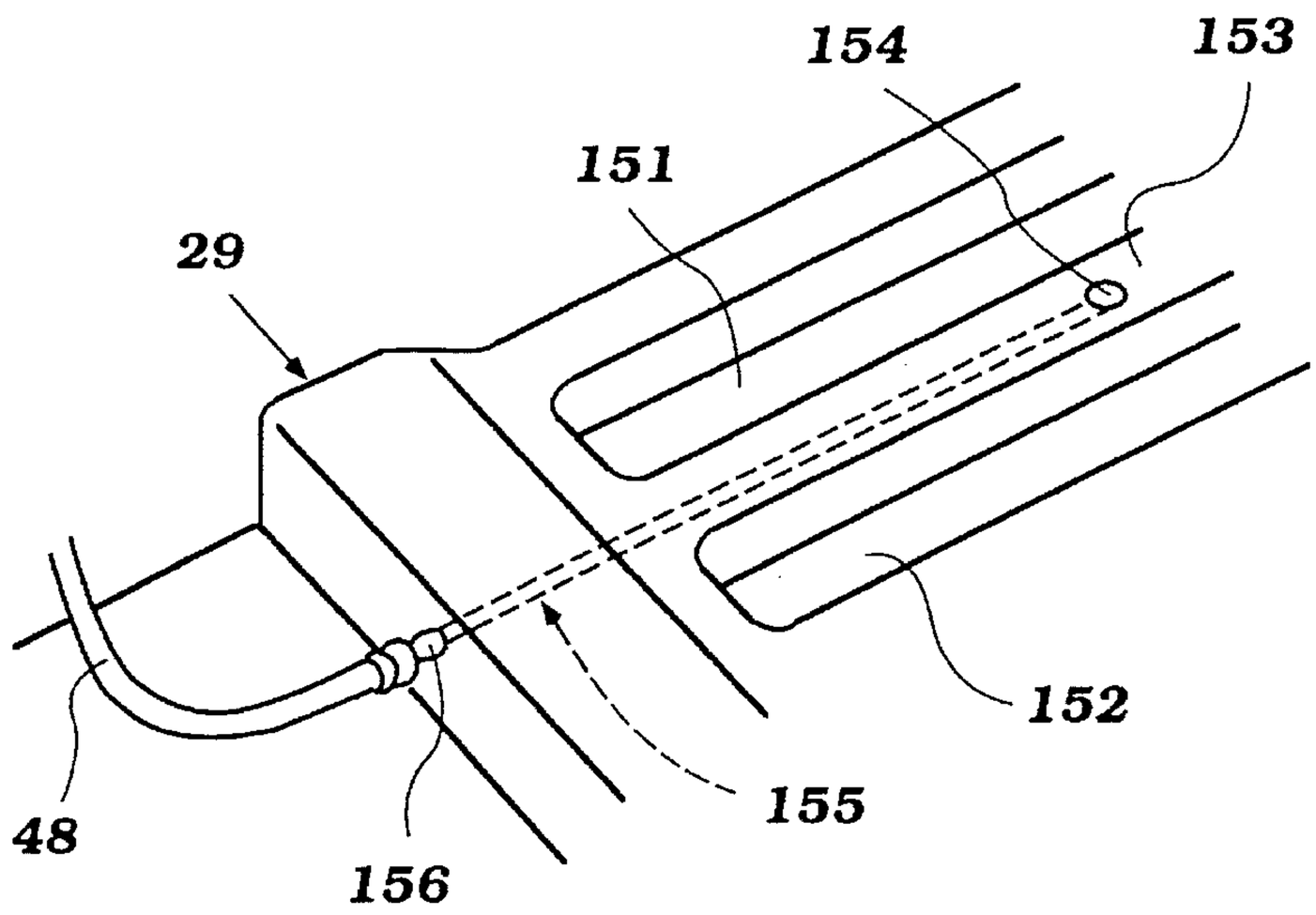

Figure 6

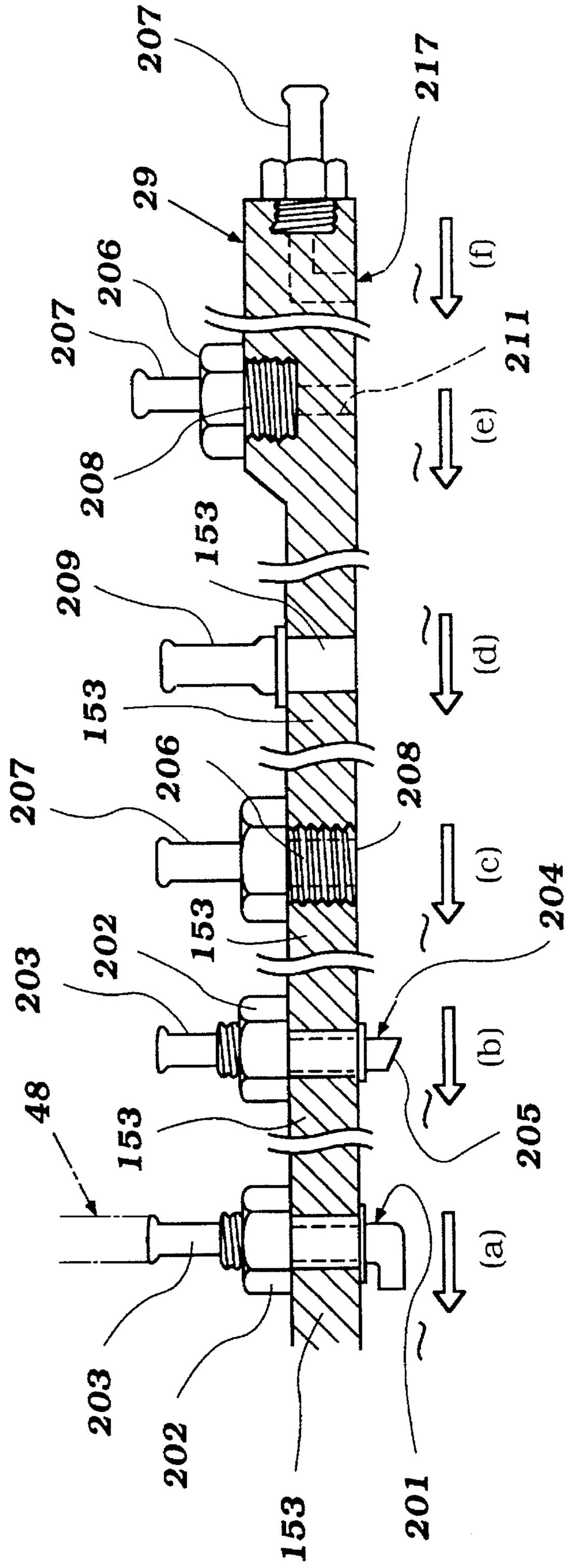
207
217
29
206
207
211
(f)
208
(e)
153
209
153
(d)
206
208
207
(c)
204
153
203
202
(b)
48
153
205
(a)
203
202
153
201

Figure 7

JET PROPULSION UNIT CONDITION INDICATOR

BACKGROUND OF THE INVENTION

This invention relates to a jet-propelled watercraft, and more particularly to a condition indicator for indicating the operating condition of the jet propulsion unit.

The advantages of jet propulsion units for propelling watercraft are well known and acknowledged. Such units permit very efficient propulsion of a watercraft and also, if concealed within a recess in the tunnel, provide a neat appearing watercraft.

There is, however, a particular problem with jet-propelled watercraft, which is shared in part with propeller-driven watercraft. That is, if the speed at which the impeller is driven is too high, then cavitation can occur, and performance deteriorates. With a jet propulsion unit it is difficult for the operator to readily discern that this cavitation condition exists. Thus, the operator is not always in a position to be able to properly control the speed at which the jet propulsion unit is driven so as to obtain optimum performance.

It is, therefore, a principal object of this invention to provide an improved and simplified indicator that will permit an operator to operate a jet propulsion unit at its optimum condition.

It is a further object of this invention to provide an improved indicator that will indicate when a cavitation condition exists in a jet propulsion unit of a watercraft.

It is a further object of this invention to provide a combined jet propulsion unit and condition indicator therefor.

SUMMARY OF THE INVENTION

This invention is adapted to be embodied in a combined water jet propulsion unit and condition indicator assembly. The assembly is comprised of an outer housing that defines a water inlet opening, a water inlet duct through which water from the water inlet opening is drawn, and an impeller housing portion in which an impeller is rotatably journalled. A discharge nozzle portion is formed downstream of the impeller portion and through which the water pumped by the impeller is discharged for providing a propulsion force to a watercraft. A condition sensor is mounted on one of the jet propulsion unit housing portions and in the path of water that flows through the jet propulsion unit.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a rear side perspective view of a watercraft constructed in accordance with an embodiment of the invention, with a portion of the hull structure broken away to show the propulsion unit.

FIG. **2** is an enlarged cross-sectional view taken through the jet propulsion unit of the watercraft and shows a number of embodiments of condition sensor locations possible in accordance with the invention.

FIG. **3** is a partial perspective view showing the components of the condition-indicating system of this embodiment

FIG. **4** is a rear elevational view showing a control panel of a watercraft constructed in accordance with another embodiment of the invention.

FIG. **5** is a cross-sectional view, in part similar to FIG. **2**, and shows a yet further embodiment of the invention.

FIG. **6** is a bottom perspective view of an arrangement wherein the condition sensor is mounted in the water inlet grill.

FIG. **7** is an enlarged cross-sectional view showing a number of different ways in which the condition sensor may be mounted in the grill of the jet propulsion unit.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS OF THE INVENTION

Referring now in detail to the drawings and initially to FIG. **1**, a small personal-type watercraft constructed in accordance with an embodiment of the invention is identified generally by the reference numeral **11**. As has been noted, the invention has particular utility with small personal watercraft, but its application is not limited thereto. Therefore, the description of the watercraft **11** will be only general in nature, and except for the jet propulsion unit and the condition-indicating device, the invention may be employed with any type of watercraft. Thus, the full details of the watercraft **11** will not be described, and where any details are omitted, the construction omitted may be assumed to be of any known type.

The watercraft **11** is comprised of a hull assembly, indicated generally by the reference numeral **12**, which includes a hull portion **13** and a deck portion **14**. These hull portions **13** and **14** may be formed from any suitable material such as a molded fiberglass reinforced resin or the like.

The rear part of the deck portion has a raised pedestal **15** which is bounded on its sides by foot areas **16** defined by raised outer gunnels **17**. A seat **18** is mounted on the raised portion **15** and is adapted to receive a rider/operator seated in straddle fashion thereon. If additional passengers are to be carried, they may be carried in a tandem fashion behind the rider/operator.

A raised control area **19** is supported to the front of the seat **18** and has a dash panel on which an instrument, in the form of a condition indicator **21** and specifically a cavitation at pressure indicator, is mounted. A handlebar assembly **22** is positioned forwardly of the instrument **21** for control of the watercraft **12** in a manner which will be described.

The area to the front of the hull **12** between the hull portion **13** and deck portion **14** forms an engine compartment, indicated generally by the reference numeral **23**. An internal combustion engine or other form of prime mover, indicated generally by the reference numeral **24**, is supported in the engine compartment **23** in a known manner. This engine **24** may be positioned at least in part beneath the front part of the seat **18** and beneath the raised control area **19**. The rear end of the engine compartment is defined by a vertically extending bulk head **25**.

The rear center underside of the hull portion **13** is provided with a tunnel area or recess in which a jet propulsion unit, indicated generally by the reference numeral **26**, is supported. The jet propulsion unit **26** is driven through a drive shaft arrangement, indicated generally by the reference numeral **27**, which affords, among other things, a flexible coupling to the output shaft of the engine **24**.

The construction of the jet propulsion unit **26** may be best understood by reference to FIG. **2**, which constitutes a longitudinal cross-sectional view taken through the center of the aforenoted tunnel and jet propulsion unit. The jet pro-

pulsion unit **26** is comprised of an outer housing that includes a water inlet portion **28** which cooperates with a grill plate **29** that is affixed to its underside and which has end portions **31** and **32** that extend forwardly and rearwardly beneath an opening **33** formed in the undersurface of the rear portion of the hull portion **13**. This grill plate **29** is formed with slots, as will be described later by reference to FIG. **6**, for removing large particles from the water that enters, as shown by the arrow **34**. This grill plate **29** serves a water inlet duct **35** formed by the housing portion **28**.

A tubular extension **36** of the housing portion **28** rotatably receives an impeller shaft **37** which extends rearwardly and which is journalled in a nacelle **38** formed within an impeller portion **39** of the jet propulsion unit **26**. The impeller portion **39** has a water inlet opening which is aligned with the outlet end of the water inlet duct **35**. An impeller **41** is fixed to the impeller shaft **37** in a known manner and is rotatably driven by the engine **24**, as aforenoted. The impeller **41** draws the water through the watercraft, as seen by the arrows **34**, and discharges it rearwardly past a plurality of straightening vanes **42** formed around the nacelle **38**.

The water is then discharged rearwardly through a discharge nozzle portion **43**, which faces in a rearward direction. A steering nozzle **44** is rotatably journalled for steering movement about a vertically extending steering axis on the discharge nozzle portion **43** by a pair of vertically disposed pivot pins **45**. The steering nozzle **44** is coupled by means of a bowden wire actuator or the like to the handlebar assembly **22** for steering of the steering nozzle **44** and for effecting steering of the watercraft **12** in a manner well known in this art.

In addition to the steering control by the handlebars **22**, other watercraft controls such as a throttle control for the engine **24** may be carried by the handlebar assembly **22**.

The underside of the rear portion of the tunnel in which the jet propulsion unit **26** is mounted is closed by means of a closure plate **46** to which the grill plate **29** may be affixed. As a result, a smooth undersurface is provided along the entire under portion of the hull, except around the grilled plate **29**.

The foregoing construction may be considered to be conventional, and for that reason, further details of the structure of the watercraft and jet propulsion unit **26**, except for the means for providing the condition signal, is not believed to be necessary to permit those skilled in the art to understand and practice the invention.

A pressure sensing port, indicated by the reference numeral **47** and shown in FIG. **1**, is disposed, in this embodiment, in an area in the impeller housing **39**. This pressure sensing port functions like a venturi tube and conveys a vacuum signal through a conduit **48** to the gauge **21**. Either within the gauge **21** or at some other location, a pressure transducer is provided which outputs an electrical signal indicative of pressure which is then converted by an appropriate conversion circuit in the gauge **21** and driver circuit so as to provide either a digital or analog signal indicative of the vacuum in the jet propulsion unit **26** which indicates that water is flowing smoothly and not cavitating.

The configuration of the pressure sensor **47** will be described later, but it will be understood by those skilled in the art that the pressure sensing port **47** may be disposed at any of a plurality of locations in addition to that described. The described location is indicated by the reference character A in FIG. **2** and is provided in the area where the straightening vanes **42** are located. Such alternate locations are, for example, at B in the grill plate **29**, at C or D in either the leading or trailing edges of the water inlet path **35** adjacent the grill plate **29**, or adjacent the upper end of the outlet of the water inlet portion **35** as indicated at E. In addition, the sensing port may be disposed at the lower side of the straightening vane portion of the impeller housing **39**, as indicated at F, or at the top or bottom of the discharge nozzle **43**, as indicated at G and H.

As may be seen in FIG. **3**, the particular connection may include a right-angle bend **49** which can face either perpendicular to or at opposite to the water flow path through the jet propulsion unit **26**. In either case the vacuum signal will be related to water flow speed.

FIG. **4** is a view showing how the speed indicator gauge **21** may be utilized in conjunction with another type of watercraft control; for example, the type of watercraft having a bench seat or individual side-by-side seats with a dash panel, indicated generally by the reference numeral **51**, being disposed to the front of the rider/operator seat. A steering wheel **52** is journalled at the lower end of the dash panel **51**, and the speedometer gauge **21** is disposed at the top of the panel **51**. It is flanked on opposite sides by other gauges such as a tachometer **53** and water speed indicator **54**. In addition, warning lights and other instruments may be mounted on the dash panel **51**.

In the embodiments of the invention as thus far described, there has been provided only one pressure pick-up point within the jet propulsion unit **26**. In some locations for the pressure pick-up point, particularly where the pickup point is disposed within the impeller housing **39**, there may be water velocity differences existent, even at the same axial location. Therefore, in order to provide accurate indication, it may be desirable to sense pressure at two different points and take the average of those pressure signals, and FIG. **5** shows such an embodiment. Except for the location of the pick-up devices and their connections, the construction of the jet propulsion unit **26** is as already described, and therefore, components of this embodiment which are the same as the previously described embodiment have been identified by the same reference numerals and will be described again only insofar as is necessary to understand the construction and operation of this embodiment.

In this embodiment there is provided a first pressure pick-up nozzle **101** in the upper area between a pair of the straightening vanes **42** and a second lower pick-up tube **102** between a pair of lower of the straightening vanes **42**. Respective conduits **103** and **104** extend from these pick-up points **101** and **102** to a junction **105** that serves the conduit **48**, which transmits the resulting average pressure signal to the gauge **21**.

FIG. **6** shows another embodiment wherein the pressure pick-up is provided directly in the grill plate **29**, and specifically between a pair of openings **151** and **152** through the bar **153** which separates these openings **151** and **152**. The pressure pick-up point is indicated at **154** and communicates with a drilled passage **155** extending through the grill plate **29** to the end adjacent the bulk-head **26**.

A nipple **156** extends therebeyond and is connected to the conduit **48**. The configuration of the pickups and the type of conduitry that may be utilized with them is illustrated in FIG. **7**, with various alternatives being shown at a, b, c, d, e, and f. The direction of water flow is indicated by the open arrows in this figure. In the a embodiment, the tube is angularly shaped, as shown at **201**, and faces rearwardly. Because of this rearward disposition, foreign objects are not likely to become lodged in the open end of the tube **201**, but it will still appropriately sense vacuum. A headed portion

202 permits attachment to the underside of the grill plate **29**, and specifically the rib **153** thereof. Hence, a nipple **203** can be formed thereon and connected to the conduit **48**.

View b shows another arrangement wherein a tubular extension **204** has a scarfed end **205** that defines an opening facing away from the flow direction and which is connected to the rib **153** in the same manner as embodiment a.

With embodiment c, the pressure pickup constitutes nothing more than a fitting having a headed portion **206** and a nipple portion **207** to which the conduit **48** may be affixed. A threaded part **208** extends into a tapped opening in the rib **153** and has an open end.

Embodiment d shows an arrangement wherein merely a nipple **209** is affixed to the underside of the rib **153**.

Embodiments e and f show connections where the pressure pickup is at the end of the grill plate **29** where it has a thicker dimension and is spaced forwardly of the grill openings **151** and **152**. The first embodiment uses a fitting like the embodiment of embodiment c, but in this case there is a smaller size opening **211** in the plate at the base of the threaded portion **208**.

Embodiment f shows a fitting like the fitting of embodiments c and e, but in this event it faces forwardly so as to provide a more compact assembly, and it cooperates with an angle-shaped drilling **217** formed in the end of the grill plate **29**.

From the foregoing description it should be readily apparent that the described embodiments provide a very effective pressure sensor for a watercraft cavitation-indicating system. The sensor can be built into the jet propulsion unit itself and will be protected upon beaching, and also will be protected from impact with foreign objects. In addition, a more accurate reading can be obtained through the use of the pressure sensor. When the operator sees a sudden drop in vacuum he will realize cavitation has occurred and can slow the engine **24** to resume stable operation.

Of course, it is to be understood that the foregoing description is that of preferred embodiments of the invention, and various changes and modifications may be made without departing from the spirit and scope of the invention as defined by the appended claims.

I claim:

1. A combined water jet propulsion unit and condition sensor and indicator, said water jet propulsion unit being comprised of a water inlet housing portion defining a water inlet opening and a water flow path, an impeller housing rotatably journalling an impeller for pumping water through said water inlet housing portion, and a discharge nozzle portion through which water pumped by said impeller is discharged for providing a propulsive force to an associated watercraft, a propulsion unit cavitation sensor mounted in one of said housing portions for providing a signal indicating that said propulsion unit is operating in a condition of cavitation and a condition indicator for receiving a condition signal from said condition sensor and displaying said condition to an operator of a watercraft powered by said water jet propulsion unit.

2. A combined water jet propulsion unit and condition sensor as defined in claim **1**, wherein the propulsion unit condition sensor comprises a pressure sensor for providing a pressure signal indicative of water flow.

3. A combined water jet propulsion unit and condition sensor as defined in claim **2**, wherein the pressure sensor comprises a tube for generating a venturi vacuum signal.

4. A combined water jet propulsion unit and condition sensor as defined in claim **1**, wherein the propulsion unit condition sensor is disposed in the water inlet housing portion.

5. A combined water jet propulsion unit and condition sensor as defined in claim **4**, further including a grilled opening across the water inlet opening and wherein the propulsion unit condition sensor is carried by the grilled opening.

6. A combined water jet propulsion unit and condition sensor as defined in claim **5**, wherein the propulsion unit condition sensor is disposed within one of the slats separating the grilled openings.

7. A combined water jet propulsion unit and condition sensor as defined in claim **6**, wherein the output from the signal propulsion unit condition sensor is transmitted through the underside of the grilled opening.

8. A combined water jet propulsion unit and condition sensor as defined in claim **7**, wherein the condition signal is transmitted out of one of the ends of the grilled openings.

9. A combined water jet propulsion unit and condition sensor as defined in claim **7**, wherein the propulsion unit condition sensor comprises a pressure sensor for providing a pressure signal indicative of water flow.

10. A combined water jet propulsion unit and condition sensor as defined in claim **9**, wherein the pressure sensor comprises a tube for generating a venturi vacuum signal forge.

11. A combined water jet propulsion unit and condition sensor as defined in claim **4**, wherein the propulsion unit condition sensor is disposed in the water inlet duct.

12. A combined water jet propulsion unit and condition sensor as defined in claim **11**, wherein the propulsion unit condition sensor comprises a pressure sensor for providing a pressure signal indicative of water flow.

13. A combined water jet propulsion unit and condition sensor as defined in claim **12**, wherein the pressure sensor comprises a tube for generating a vacuum signal.

14. A combined water jet propulsion unit and condition sensor as defined in claim **1**, wherein the propulsion unit condition sensor is formed in the jet propulsion unit housing to the rear of the impeller.

15. A combined water jet propulsion unit and condition sensor as defined in claim **14**, wherein the propulsion unit condition sensor is provided in the area immediately behind the impeller.

16. A combined water jet propulsion unit and condition sensor as defined in claim **15**, wherein there are provided a plurality of straightening vanes in the impeller housing portion to the rear of the impeller and wherein the condition sensor is disposed in the straightening vane area.

17. A combined water jet propulsion unit and condition sensor as defined in claim **16**, wherein the propulsion unit condition sensor comprises a pressure sensor for providing a pressure signal indicative of water flow.

18. A combined water jet propulsion unit and condition sensor as defined in claim **17**, wherein the condition sensor comprises a tube for generating a vacuum signal.

19. A combined water jet propulsion unit and condition sensor as defined in claim **14**, wherein the propulsion unit condition sensor is disposed in the discharge nozzle housing portion.

20. A combined water jet propulsion unit and condition sensor as defined in claim **19**, wherein the propulsion unit condition sensor comprises a pressure sensor for providing a pressure signal indicative of water flow.

21. A combined water jet propulsion unit and condition sensor as defined in claim **20**, wherein the pressure sensor comprises a tube for generating a vacuum signal.

22. A combined water jet propulsion unit and condition sensor and indicated as set forth in claim 1, in combination with a watercraft having a hull propelled by said water jet propulsion unit, an engine carried by said hull for driving said water jet propulsion unit, a rider's area in said hull, said condition indicator being mounted in said hull in said rider's area.

23. A combined watercraft as set forth in claim 22, wherein the rider's area defines a control for operation by a rider and wherein the condition indicator is juxtaposed to said control.

24. A combined watercraft as set forth in claim 23, wherein the rider's area is provided with a straddle-type seat on which a rider/operator may be seated therein, the condition indicator and control is disposed forwardly of said seat.

25. A combined water jet propulsion unit and condition sensor comprised of a water inlet housing portion defining a grilled water inlet opening and a water flow path, an impeller housing rotatably journalling an impeller for pumping water through said water inlet housing portion, and a discharge nozzle portion through which water pumped by said impeller is discharged for providing a propulsive force to an associated watercraft, and a propulsion unit condition sensor mounted within one of the slats separating the grilled openings.

26. A combined water jet propulsion unit and condition sensor as defined in claim 25, wherein the output from the propulsion unit condition sensor is transmitted through the underside of the grilled opening.

27. A combined water jet propulsion unit and condition sensor as defined in claim 26, wherein the condition signal is transmitted out of one of the ends of the grilled openings.

28. A combined water jet propulsion unit and condition sensor as defined in claim 26, wherein the propulsion unit condition sensor comprises a pressure sensor for providing a pressure signal indicative of water flow.

29. A combined water jet propulsion unit and condition sensor as defined in claim 28, wherein the pressure sensor comprises a tube for generating a venturi vacuum signal.

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